Effect of Long-Chain Branch and High Molecular Weight Components on Contraction Flow Behavior – In-situ Observation of polymer melts

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1.Introduction:

Polymer is typical viscoelastic fluid and the rheological property strongly affects the flow behavior under polymer processing. The sudden change of flow channel influence the flow behavior of polymer melts because viscoelastic fluids have memory effect. So far, study on the flow behavior in an abrupt channel was mainly carried out for polymer solutions due to the difficulty of visualization.

This study reports polymer melts behavior with different polymer chain structure in contraction channel by in-situ observation system.

2. Sample & Experiment

We used 3 polyethylenes: high density polyethylene (MFR=2, HD), tubular process LDPE (MFR=5, LD-t), third sample is vessel process LDPE (MFR=3.7, LD-v). Fig.1 shows extruder and in-situ observation system. Extruder is twin extruder (ϕ=15mm, L/D=30). The die geometry is contraction. We used a die of 180° entry slit geometry of 5mm depth, 5mm width and 5mm length, with an entry contraction ration of 4:1. Contraction ratio is 4:1. In-situ observation system consists of confocal laser microscope and high-speed camera, laser, scanner etc. Tracer is fluorescence particle ($\phi_{average}$=3μm).

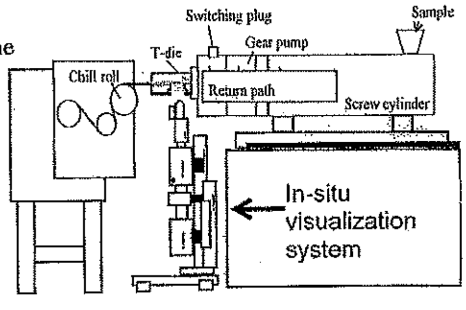

Fig. 3 Experiment device

3. Results & Discussion

For flow analysis captured 2000 flames were superposed (2sec, 1000fps). Fig.2 shows melt flow through contraction geometry. HD shows natural entry profile like Newtonian fluid (Fig.2).

On the other hand, the characteristic flow patterns for LDPEs are shown in Fig.2 (b, c). Vortex at corner can be observed for LD-t. The velocity in the vortex is much slower than that of HD in the corners. Furthermore larger vortex was formed for LD-v comparing with LD-t. When comparing LD-v with LD-t, the natural entry and vortex boundary moved towards upstream and entrance of slit. Since LD-t, and v showed almost same complex viscosity $|\eta^*|$ curves within experimental frequency, those flow behavior as shown in Fig.2 cannot be explained by the linear viscoelasticity. We will discuss the flow behavior in abrupt contraction flow in terms of non-linear elongational properties.

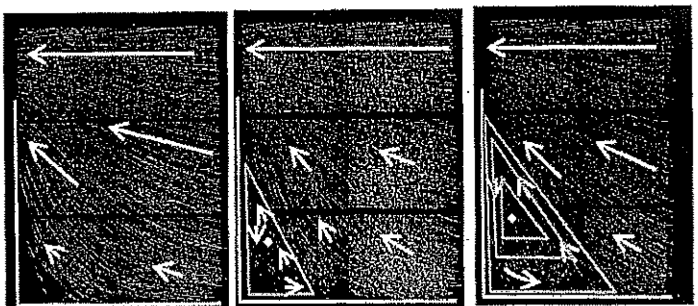
(a) HD (b) LD-t (c) LD-v

Fig.2 Melt flow through contraction geometry for HD (190°C), LD-t and m(140°C). Size of image is 10.5*8 mm. Arrow is flow direction.